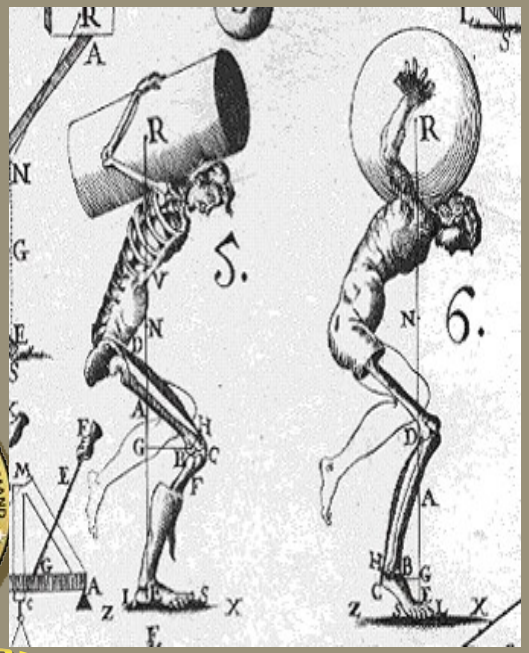
INTERNATIONAL SOLDIER SYSTEMS CONFERENCE AND EXHIBITION 2004

Military Biomechanics: Understanding Load Carriage

Leif Hasselquist, Ph.D., ATC



G. Borelli 1680

Afghanistan 2003

FFW 2010

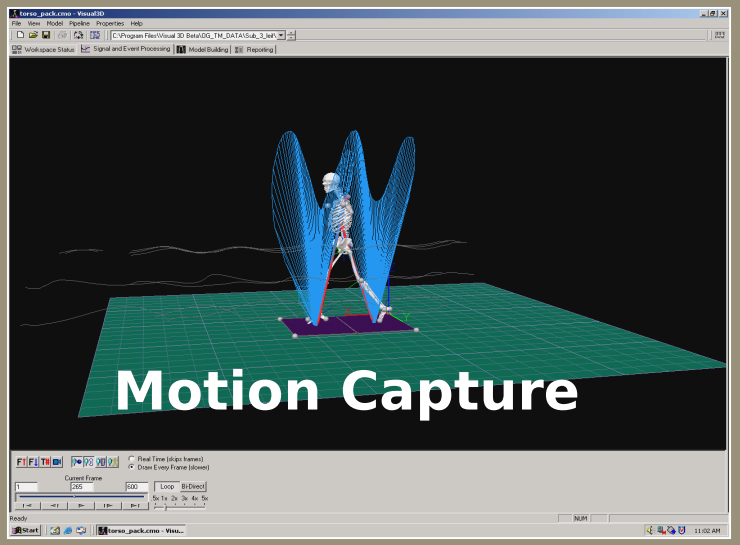
The Science Behind the Warrior: Yesterday, Today and

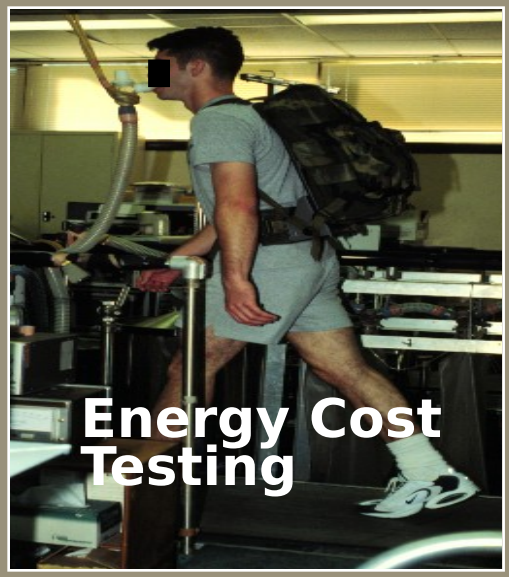
US ARMY NATICK SOLDIER CENTER | Kansas Street | Natick, MA • 01760 •
NSC NATICK ARMY

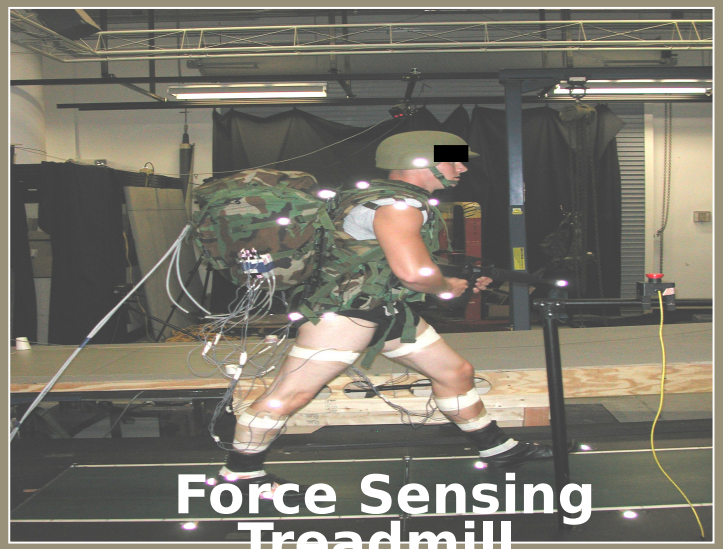
Center for Military Biomechanics Research

- **Joint Research Facility**
  - **U.S. Army Natick Soldier Center**
  - **U.S. Army Research Institute of Environmental Medicine**
  - **Constructed in FY94**
  - **7,000 Square Foot State-of-the-art Facility**
- **Supplemental Personnel**
  - **Mathematicians**
  - **Anthropometrists**
  - **Modelers**
  - **Cognitive Psychologists**
- **CMBR Core Personnel:**
  - **Carolyn K. Bensel, Ph.D.**
  - **Peter Frykman, M.S.**
  - **Everett Harman, Ph.D.**
  - **Leif Hasselquist, Ph.D., ATC**
  - **Karen P. Norton, M.S.**
  - **John P. Obusek, Sc.D., PT**
  - **Jeffrey M. Schiffman, Ph.D**
- Applications
  - Personal Equipment Design
  - Enhanced Physical Performance
  - Military Job/Task Analysis and Design
  - Injury Prevention and Reduction

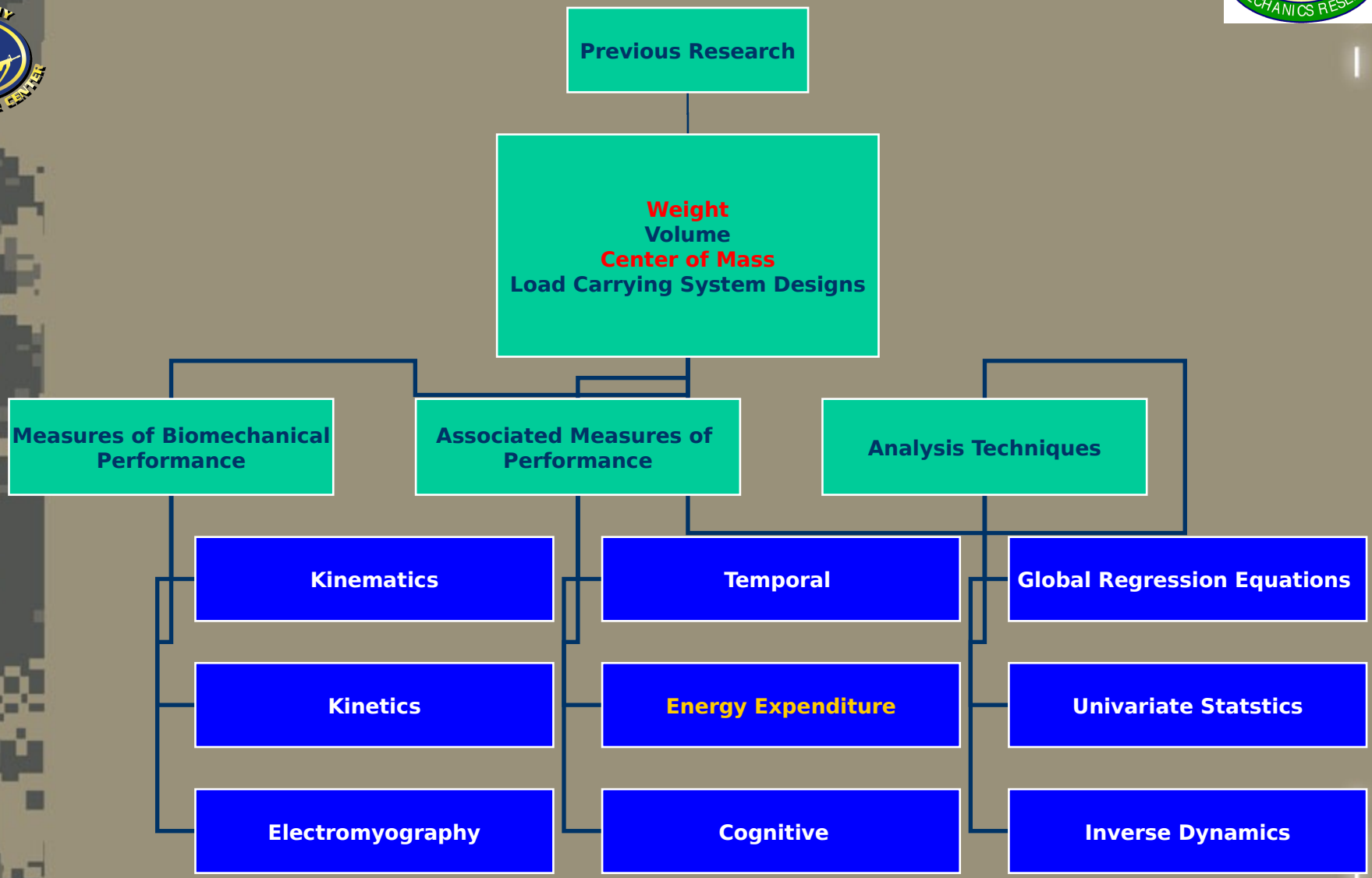
Center for Military Biomechanics Research







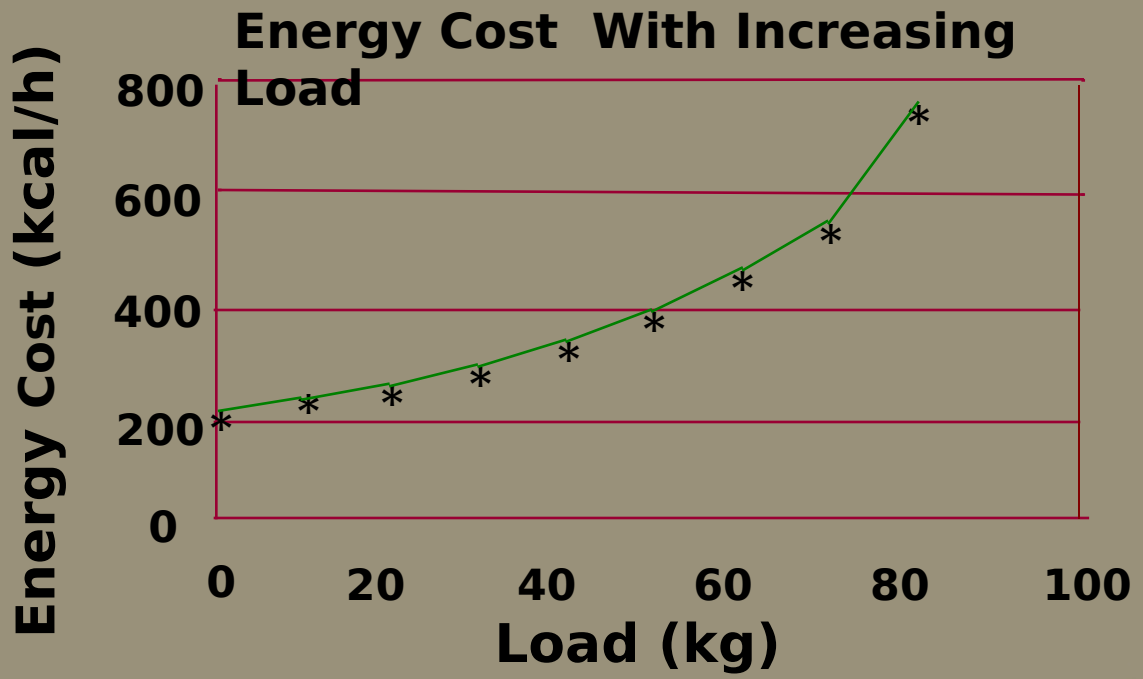
Load Carriage Research



Previous Research

Increase in Energy Cost With Load

- Subject Weight
- Carried Load
- Walking Speed
- Terrain
- Slope

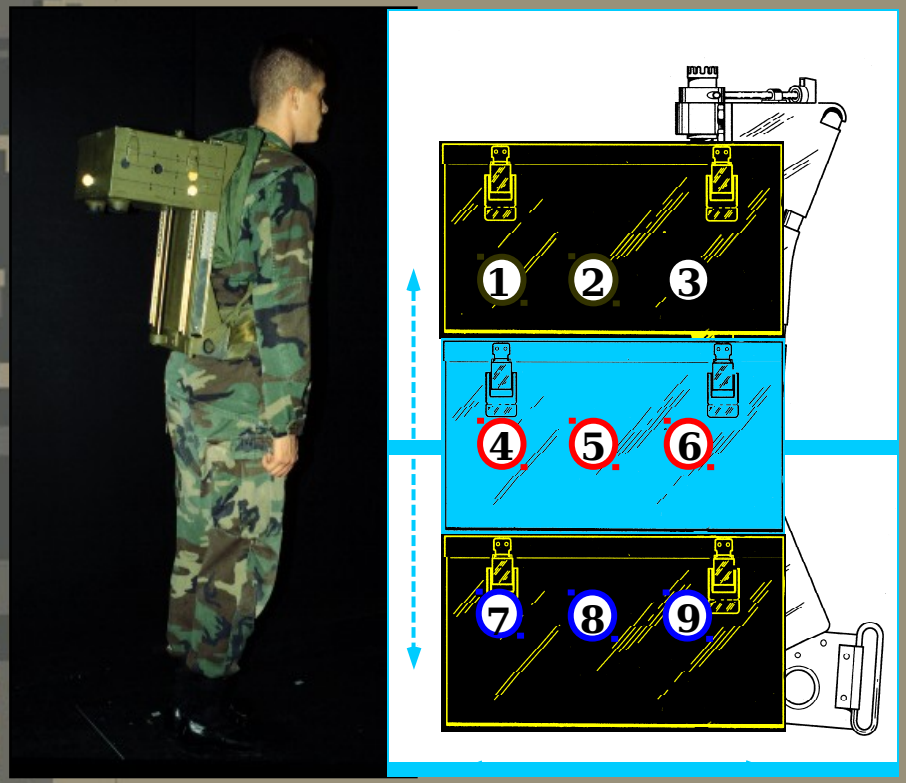


(Pandolf et al., 1977)

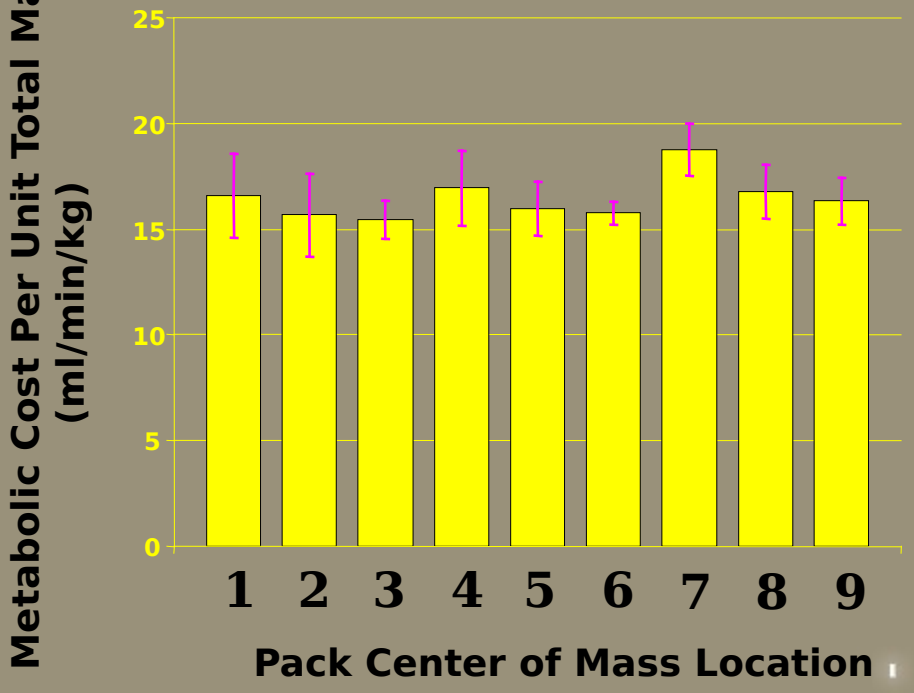
Previous Research

Center of Mass Effect: Physiological

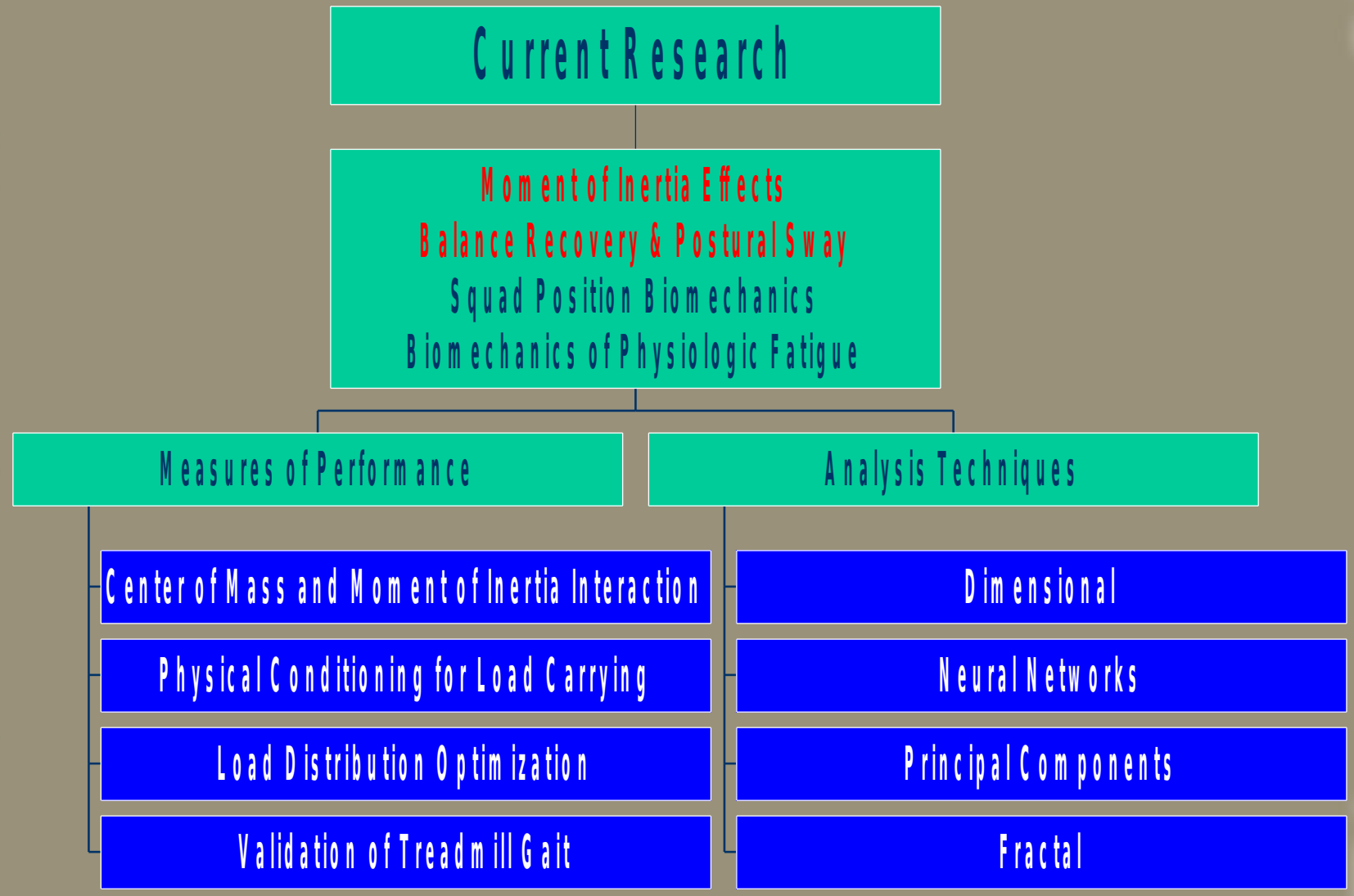
Fabricated Backpack



✓ *24% Difference in Energy Cost*
Position 3 vs. Position 7



Load Carriage Research



Current Research

Mortar Assistant

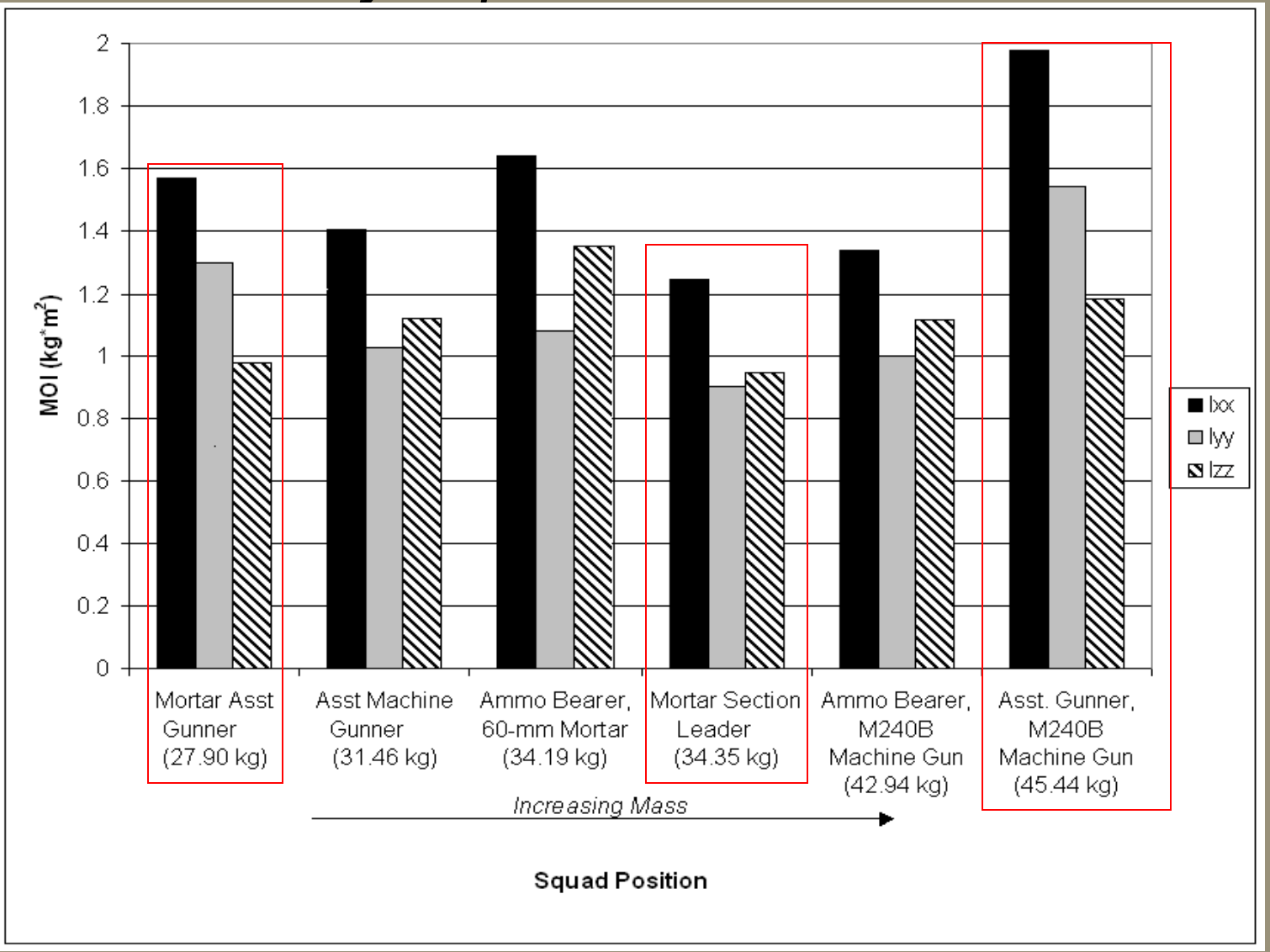
Moment of Inertia

Resistance of a body to changes in its motion

$I = mr^2$

Current Research

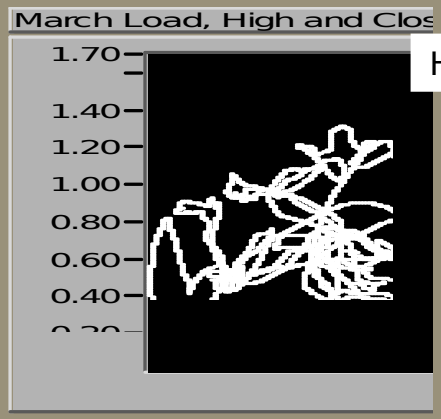
MOI by Squad Position



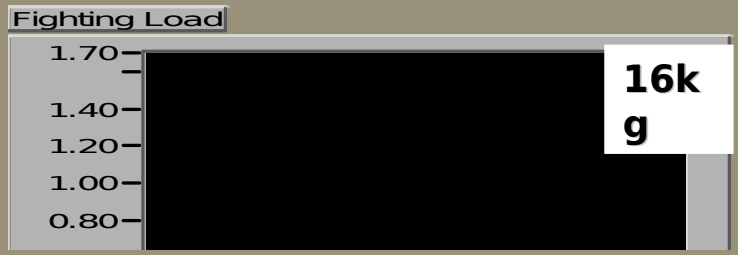
Current Research

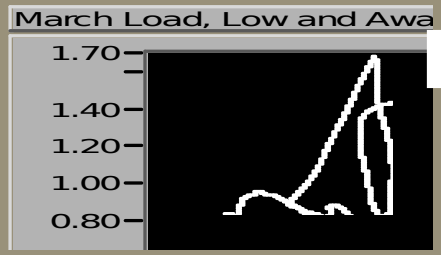
Postural Sway

- Load Weight
  - Loads of 6 kg, 16 kg, 40 kg
  - ↑ load → ↑ excursion
- Position of Load
  - Low and away
  - High and close



High & Close 40 kg





Low & Away 40 kg

Load Carriage Research

Future Research

Modeling of Load Carriage on Grades and Over Uneven Terrain
Optmization of Load Carriage to Enhance Mobility, Comfort, and Dynamic Suspension Systems

Measures of Performance

Traditional Measures
- Biomechanics
- Localized Muscular Fatigue Monito
- Energy Cost

Non-traditional Measures
- Floroscopy or MRI
- Physiologic Fatigue Monitoring
- Dynamic Stability

Time Based Changes
- Walking Gait
- Cognition

Analysis Techniques

Genetic Algorithms for 3-D Packing

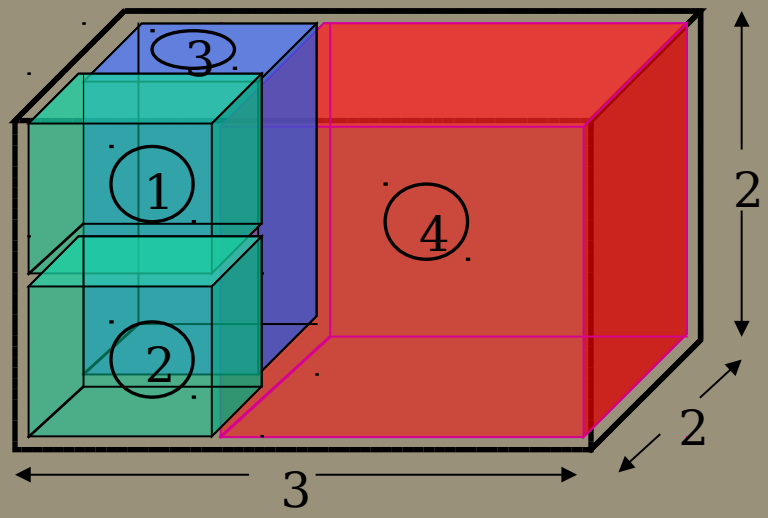
Hybrid Dimensional and Statistic Anal

3-D Scanning/Modeling for Determini Human Segmental Mass Properties

Future Research

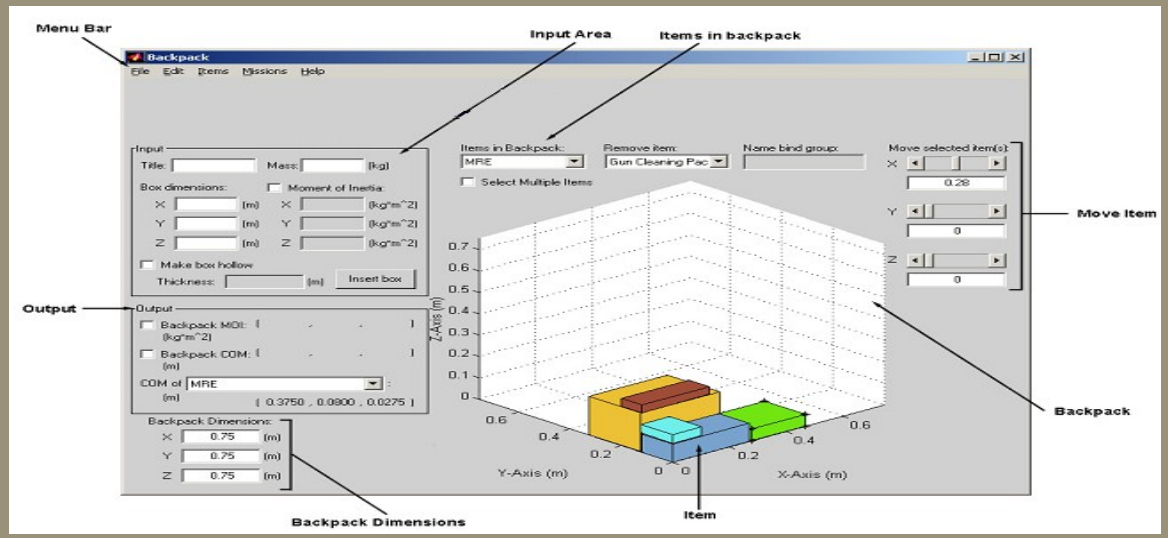
Load Distribution Optimization

Partitioning Feasible Solutions and Search Domain



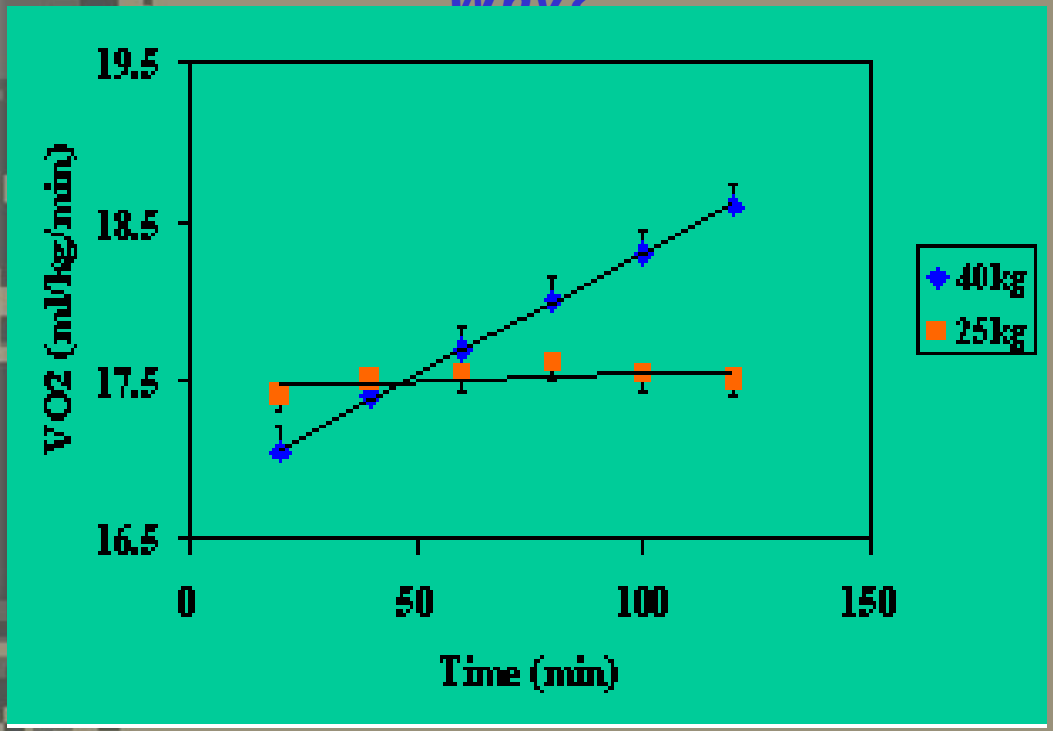
Four-Piece Example Problem

Graphical User Interface



Future Research

Prolonged Load Carriage - Oxygen Uptake Increases Over Time
Why?



Epstein, Eur J Appl Physiol 57:243, 1988

2005 CMBR Research

Biomechanical, Muscular, and Cognitive Responses Associated with Prolonged Load Carriage

- **Energy Cost**
- **Biomechanical Parameter Changes**
- **Localized Muscle Fatigue**
- **Effects on Cognitive Performance: Correlations with Physiological and Biomechanical Indices**

Thank You
Any Questions?

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